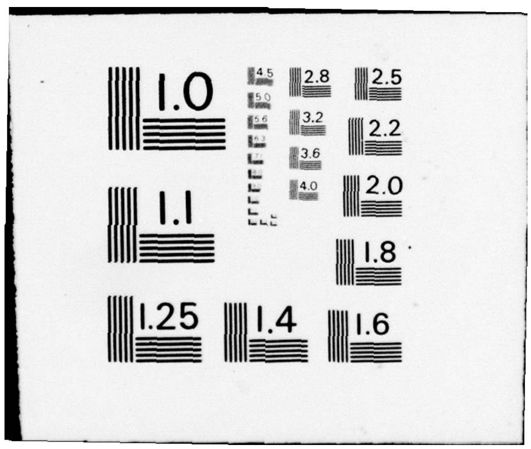
AD-A032 431 NAVAL INTELLIGENCE SUPPORT CENTER WASHINGTON D C TRA--ETC F/G 13/10
CALCULATING FUEL SUPPLIES AND ENDURANCE OF FAST HYDROFOILS (RAS--ETC(U)
SEP 76 V M PASHIN

UNCLASSIFIED NISC-TRANS-3854 NL

1 OF 1
ADA032431

END
DATE
FILMED
1 -77


1.0
4.5
5.0
5.6
6.3
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

AD A032431

3

FC

DEPARTMENT OF THE NAVY
NAVAL INTELLIGENCE SUPPORT CENTER
TRANSLATION DIVISION
4301 SUITLAND ROAD
WASHINGTON, D.C. 20390

CLASSIFICATION: UNCLASSIFIED

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

TITLE: (6) Calculating Fuel Supplies and Endurance of Fast Hydrofoils

(Raschety zaposov topliva i dal'nosti plavaniya bystrokhodnykh sudov na podvodnykh kryl'yakh),

(10)

AUTHOR(S): V. M. Pashin, V. M.

PAGES: 6

(21) Trans. of

SOURCE: Sudostroyeniye, No. 2, 1964
~~Pages 12-14~~

(USSR) n2
p12-14 1964.

DDC
RECEIVED
NOV 23 1976
C

ORIGINAL LANGUAGE: Russian

TRANSLATOR: DM

(12) 7p.

(14)

NISC-TRANS[redacted] - 3854

APPROVED P.T.K.

DATE 22 Sep[redacted]76

(11)

407 682

CALCULATING FUEL SUPPLIES AND ENDURANCE OF FAST HYDROFOILS

[Pashin, V. M. Raschety zapasov topliva i dal'nosti plavaniya bystrokhodnykh sudov na podvodnykh kryl'yakh; Sudostroyeniye, No. 2, 1964, pp. 12-14; Russian]

In the case of a given speed for a ship under design, the fuel supply required is determined by the distance navigated or cruise duration and the hourly fuel consumption. Usually in the planning stage it is assumed that fuel consumption is proportional to engine power[1]

---

1 Only fuel consumption of main engines, piston or turboprop, is examined.

$$G_T = 10^{-3} g_T N \frac{L}{v_s}$$

where G_T is the fuel weight (t); g_T is fuel consumption (kg/hp·hr); N is main engine power (hp); L is range (miles); v_s is ship speed (knots).

After expressing the required power in terms of drag and speed and then in terms of the corresponding parameters of the foil system we can obtain

$$G_T = \frac{g_T L}{146 \frac{c_y}{c_x} \eta} G; \qquad (1)$$

$$L = \frac{146}{g_T} \cdot \frac{c_y}{c_x} \eta \frac{G_T}{G}, \qquad (2)$$

A

where G is the ship weight or displacement (tons); c_y and c_x are the coefficients of lift and drag; η is the propulsive efficiency.

Because of the high power requirements compared with conventional ships, large fuel supplies reaching in some cases 30-35% of ship weight are characteristic of fast hydrofoils.[2] As the cruise progresses, the

---

2 Transactions of the Society of Naval Architects and Marine Engineers, 1959, vol. 67, pp. 686-714.

---

required power and speed change considerably when compared with ships with full supplies.

Consequently, the total value of ship range is determined as follows:[3]

---

3 Here and later only the technical ship range is examined without taking into account the navigational fuel supply which is established by special requirements put on the ship and can amount to 5-10% and more of total fuel supply.

$$L = \int_{G-G_T}^{G} \frac{146}{g_T} \cdot \frac{c_y}{c_x} \eta \frac{dG}{G}.$$

Depending on the kind of power plant control, two cases are possible when integrating this expression.

1. At each given time moment the thrust of the propellers is kept equal to the thrust needed to move the ship at a given constant speed; the required power decreases during the course of the cruise due to the

reduced ship weight. In this case the integrand $\frac{146}{g} \times \frac{c_y}{c_x} \eta$ can be considered independent of G.

2. The power delivered to the propellers is constant throughout the cruise. Ship speed increases because of reduced weight.

The integrand in this case is a function of G, since the factor $\frac{c_y}{c_x} \eta$ changes as speed changes.

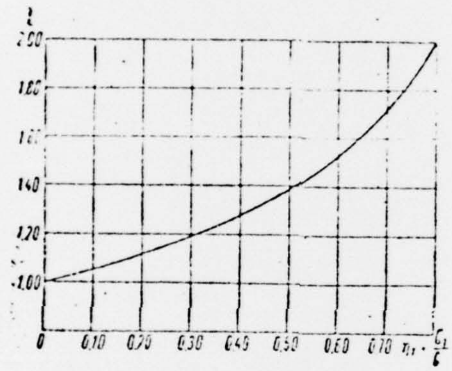


Fig. 1. Value $\bar{L}$ as a function of fuel fraction of ship weight.

In the first case the ship range given specific fuel supplies is obtained as equal to

$$L = \frac{146}{g_T} \cdot \frac{c_y}{c_x} \eta \ln \frac{G}{G - G_T}. \qquad (3)$$

The results of comparing ship ranges as determined by equalities (2) and (3) are shown in Fig. 1. Value $\bar{L}$ is obtained by term-wise division of equality (3) by (2).

As Fig. 1 shows, when $\eta_T = \frac{G_T}{G} > 0.15\text{-}0.20$, the actual ship range (3) substantially exceeds (by 12-15% and more) the conditional range (2).

If in the planning of a ship a specific range is given, then the

required fuel supplies are

$$G_{т} = \frac{e^{x} - 1}{e^{x}} G, \qquad (4)$$

where

$$x = \frac{g_{т} L}{146 \frac{c_y}{c_x} \eta}.$$

To what extent the actual necessary fuel supply differs from that obtained by calculations using formula (1) can be found using the graph of Fig. 2 compiled on the basis of the equality

$$\overline{G}_{т} = \frac{(e^{x} - 1)(1 - x)}{x}. \qquad (5)$$

The latter was obtained by term-wise division of modified equalities (4) and (1).

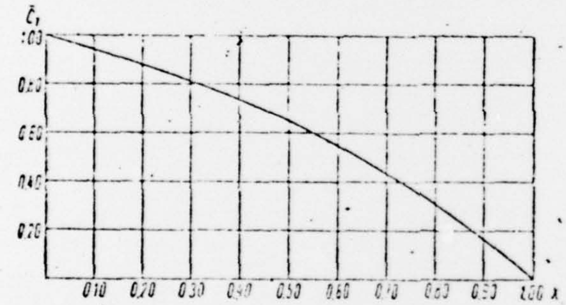


Fig. 2. Value $\overline{G}_T$ as a function of parameter x.

It is known that the value x on fast hydrofoils can reach 0.30-0.35 and more. In this case the actual necessary fuel supplies will be 20-25% less than those calculated using relationship (1).

In the case where the power delivered to the propellers is constant throughout the entire cruise, the speed will increase as the ship's weight decreases, while the value of factor $\frac{c_y}{c_x}\eta$ entering the integrand for L will correspondingly decrease.

The ship's range as a function of fuel supplies in this case is calculated for a specific ship weighing 325 tons, having an operational

speed of 50 knots, and engine power of about 16,000 hp.

Fig. 3 shows how as ship weight decreases (due to fuel consumption) the speed increases and the factor $\frac{c_y}{c_x}\eta$ drops accordingly. According to Fig. 3

$$\frac{c_y}{c_x}\eta = f(G) = 0.015G + 2.05.$$

Then the expression for determining the ship's range takes the form

$$L = \int_{G-G_T}^{G} \frac{146}{g_T}\frac{c_y}{c_x}\eta\frac{dG}{G} =$$

$$= \frac{2.19}{g_T}G + \frac{300}{g_T}\ln\frac{G}{G-G_T}. \qquad (6)$$

The results of calculations based on formulas (2), (3), and (6) have shown that the greatest ship range is obtained in the case where at each given time moment the thrust of the propellers is kept equal to the thrust required to move the ship at a given constant speed.

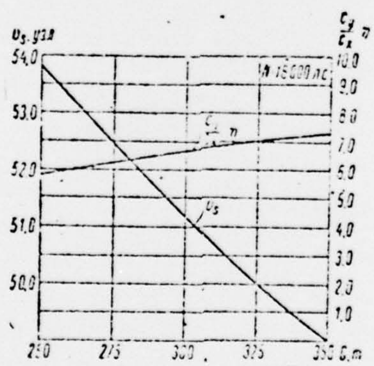


Fig. 3. Speed and factor $\frac{c_y}{c_x}\eta$ as function of ship weight.

Analogous results are obtained for hydrofoils using turbojet or turbofan engines.

Calculations of ship ranges and fuel supplies applicable to this case are performed using the relationships

$$L = \frac{1}{g_{\mathrm{T}}} \cdot \frac{c_y}{c_x} v_s \ln \frac{G}{G - G_{\mathrm{T}}}; \tag{7}$$

$$G_{\mathrm{T}} = \frac{e^x - 1}{e^x} G, \tag{8}$$

where

$$x = \frac{g_{\mathrm{T}} L}{\frac{c_y}{c_x} v_s}.$$

Values of $\overline{L}$ and $\overline{G}_T$ can be obtained using the graphs in Figs. 1 and 2.

Conclusions

Taking into account the change in hydrofoil weight during the course of a cruise, the range can be increased 20-25% when $\frac{G_T}{G} = 0.30\text{-}0.35$ (or fuel supplies correspondingly decrease 20-25% given a fixed range).

The greatest range given specific fuel supplies on hydrofoils can be achieved in the case when at each given time moment the thrust of the propellers (in the case of turbojet engines -- engine thrust) is equal to the thrust required to move the ship at a constant speed.

From the editorial office: Questions related to designing fast hydrofoils are currently drawing great attention. The editorial office proposes in the next issue to print an article by V. Yu. Tikhoplav which was submitted at the same time as the article by engineer V. M. Pashin also dealing with special problems in designing these ships taking into account their diminishing weight as fuel is consumed.